Survey of the abundance of the ornate rock lobster *Panulirus ornatus* stock in PNG waters of Torres Strait

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EXECUTIVE SUMMARY

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PROJECT

Survey of the abundance of the ornate rock lobster *Panulirus ornatus* stock in PNG waters of Torres Strait

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DATE OF COMMENCEMENT 1 May 1998

DATE OF COMPLETION 14 May 1999
AIMS OF THE PROJECT

(i) Estimate the size of the *Panulirus ornatus* stock in PNG waters of Torres Strait.

(ii) Determine the geographic distribution of recruiting and fished *Panulirus ornatus* in PNG waters of Torres Strait.

(iii) Determine the size distribution of *Panulirus ornatus* in PNG waters of Torres Strait.

DESCRIPTION OF WORK

The sampling design for the lobster stock survey was conducted during May 1998 by CSIRO DMR in collaboration with PNG NFA. Methods were similar to those used by Pitcher et. al. (1992) to survey the abundance of *Panulirus ornatus* in Torres Strait during 1989. Prior to the survey the seabed habitats within the 2474 km² study area were mapped using historical information maintained by CSIRO in the Torres Strait Geographic Information System (GIS). From this habitat information, a total of 12 sampling strata were identified and mapped. The area of each stratum was estimated using Arcview 3.0 and a total of 68 sampling locations (each with 2 sites) were allocated to the 12 strata at either high (1 location per 20.25 km²) or low (1 location per 36 km²) density, dependent on the suitability of the habitat in the strata, for lobsters. Sixteen of the sites sampled during the 1989 survey were sampled again. The primary sampling unit at each site was a 500m by 4m belt transect, surveyed by 2 divers.

Field sampling was conducted during 24 June to 1 July 1998. A total of 76 sites were surveyed by divers and a further 57 sites with sub-optimal habitat for lobsters or deep water were surveyed using underwater video. At each site observers recorded: number of lobsters observed, percent of each substratum type and percent of all dominant and conspicuous biota (including algae species, seagrass species, corals, pearlshells and holothurian species). All lobsters captured by divers were sexed and measured (tail width in mm).

The data on number of lobsters per transect, transect habitats and lobsters sizes were stored in a Microsoft Access database and the geographic distribution of lobsters and seabed habitats was mapped using Arcview 3.0. Mean lobster abundances and standard errors were estimated for each sampling stratum and the overall lobster abundance and error estimate for the entire study area were calculated as the sum of these estimates. The stock biomass was calculated as the product of the abundance estimate and mean tail weight of the lobsters sampled during the survey. This biomass was compared with the 1998 commercial catch to give an estimate of the current exploitation. The year-class components in the size-frequency distribution were separated using the component analysis program Mix 3.0 (Macdonald and Pitcher, 1979). Lobster counts at sites repeated in 1989 and 1998 were compared using a paired t-test.

RESULTS, CONCLUSIONS AND ASSESSMENTS

The survey of the abundance of *Panulirus ornatus* in PNG waters of Torres Strait was completed by CSIRO and PNG NFA staff who counted lobsters at 133 sites in the ~2500 km² study area during June/July 1998. Lobsters were found in a restricted range of habitats, on deep rocky seabed or near the more exposed reef edges at only 46 (~35%) sites. The seabed habitat to
the west and east of the Warrior Reefs was predominantly mud/sand and no lobsters were found there.

The estimate of lobster abundance in PNG waters of Torres Strait was 460,000 (± 50%), of which 58% came from one sampling stratum (Gimini hard substrate) located north-west of Auwamaza reef, which represented only 12% of the total area. The estimated stock biomass, given a mean tail weight of the sampled lobsters of 297 g, was ~137 t.

The size distributions of lobsters in the land-based and freezer boat sectors of the PNG fishery compared with the size distribution of sampled lobsters showed that the fishery exploits the full size range of the population. The fishery catch between August 1997 and July 1998 was ~ 80 t which indicated that fishers currently exploit about 60% of the standing stock (~137 t).

Recruiting (1+) and fished (2+ and 3+) lobsters occupied similar habitats in the study area and it would be impossible to designate closed areas to conserve recruits without restricting access to 2+ lobsters. However, about 30% of the lobsters observed were found in water depths >20 m; depths not readily accessible to most commercial divers. Thus, lobsters in these deep areas comprise a reservoir population that would not be exploited, unless they move into shallower water.

The effect of imposing a minimum size limit to optimise yield per recruit (YPR) was recently assessed using a fishery model developed for the Australian fishery and the model showed that setting a minimum size would only significantly increase YPR if fishing mortality was high (F>1.0). Given that the current study indicates that ~60% of the stock is exploited, it is likely fishing mortality currently exceeds 1.0. It is therefore likely that imposing a size limit, particularly in the land-based sector, would increase YPR and increase total annual catch.

This study provides a baseline for future studies of the abundance and distribution of *Panulirus ornatus* and status of the PNG lobster fishery and established sampling sites that may be used for future fishery-independent surveys of the lobster stocks. Such surveys would compliment surveys conducted annually by CSIRO in Australian waters of Torres Strait and would complete the coverage of Torres Strait.
1. INTRODUCTION

1.1 Background

The ornate rock lobster *Panulirus ornatus* supports locally important artisanal and commercial fisheries for both Australia and Papua New Guinea in Torres Strait. These fisheries are managed under the Torres Strait Treaty, which was ratified in 1985, with the main objective to ensure sustainable development of the fishery for the long-term benefit of the indigenous inhabitants. To achieve this objective there has been considerable ecological and fisheries research conducted by the PNG DFMR and NFA and by CSIRO Australia, and there is a long history of research collaboration between these agencies. In recent years, research by both countries has been directed principally at assessment of the commercial fisheries for management. In 1989, the biomass of the Torres Strait lobster stock was estimated at 2200 – 3350t tail weight, during a collaborative PNG/Australia research program. This allowed the first estimate of exploitation rate at ~10%, given a combined annual catch of ~300t. Since 1989, Australia has undertaken stock monitoring programs to assess the level of impact of fishing on the lobster population, and this research indicates that the exploitation rate may now be greater than 25%. Both PNG and Australia monitor commercial fishing using logbook programs.

The PNG fishery provides a major source of employment and income for the inhabitants of Daru and surrounding coastal villages and annual catch has increased markedly in recent years, from less than 40 t prior to 1985 to greater than 80 t after 1993 (Fig. 1), as a result of increased participation. There are currently over 500 divers involved in the PNG Torres Strait lobster fishery. Monitoring of commercial catch and effort by PNG NFA suggests that CPUE levels have remained stable in recent years, but mean size of lobsters in the catch has decreased (Poiner et al, 1998), suggesting fishers are targeting smaller lobsters to maintain catch rates. The recent trend in increased fishing pressure, and the probability of even more participation, has raised concerns as to the long-term sustainability of this fishery.
The need to determine the distribution and abundance of the *Panulirus ornatus* stock in PNG waters of Torres Strait was identified following a recent assessment of the PNG fishery using commercial catch data maintained by PNG NFA (see Final Report No. FIS/96/81, June 1998). The current project is a follow-on research project aimed at addressing this information gap and providing information essential for efficient management of the fishery.

### 1.2 Objectives

**1.2.1 Estimate the size of the *Panulirus ornatus* stock in PNG waters of Torres Strait.**

The most fundamental parameter, essential for fisheries management is stock size. The precision of this estimate is determined by the specific requirements of managers and consideration of cost-effectiveness of the sampling program. When compared with annual catch, managers have a simple but effective measure of the impact of fishing on the lobster population. Estimation of absolute stock size provides a baseline measure for comparison with future surveys of lobster abundance by the PNG NFA, such as commercial catch monitoring or relative abundance surveys (eg. annual population surveys conducted by CSIRO).

**1.2.2 Determine the geographic distribution of recruiting and fished *Panulirus ornatus* in PNG waters of Torres Strait.**

An understanding of the distribution of lobsters in Torres Strait PNG is necessary for effective management of the resource. This information allows managers to assess what proportion of the population is accessible to fishers (the main restriction being water depth) and what proportion is essentially a reservoir sub-population. Information on the distribution of recruiting lobsters enables managers to assess the efficiency of possible area closures and/or seasonal closures that may reduce the impact of fishing or increase yield per recruit.
1.2.3 **Determine the size distribution of *Panulirus ornatus* in PNG waters of Torres Strait.**

Determination of the size distribution of Torres Strait PNG lobsters is a necessary part of estimating absolute lobster abundance so that component year-class abundances, fishable-stock biomass, and growth rates can be estimated for preliminary stock status assessment.

1.3 **Description of the project**

The size of the *Panulirus ornatus* stock in PNG waters of Torres Strait was estimated by CSIRO DMR and PNG NFA staff conducting visual censuses (divers and video) of 133 belt transects during June/July 1998. The transects were allocated at random to each of 12 sampling strata in the 2500 km$^2$ study area. Lobsters were captured and measured and the size distribution of these sampled lobsters was analysed using component analysis “Mix 3.0” (MacDonald and Pitcher, 1979) to estimate the proportions of each year-class in the population. The stock abundance estimate was converted to a biomass estimated using the mean tail weight of sampled lobsters. Stock biomass was then compared with the 1998 PNG commercial catch to give an estimate of the current exploitation by the fishery.

This project served to continue and strengthen links established between the CSIRO DMR and PNG NFA. Collaboration between these agencies began in the early 80’s when researchers conducted extensive tagging studies to determine the lobster migration routes. In 1989, researchers from CSIRO and PNG DMFR (now PNG NFA) estimated the size of the lobster stock in Torres Strait. Between 1996 and 1998, CSIRO researchers collaborating with PNG NFA staff, conducted a preliminary assessment of the lobster stock in Torres Strait PNG, using commercial fishery data-sets, and identified gaps in information necessary for efficient fishery management. In the current project, aimed at addressing one of the identified information gaps, stock size, PNG NFA staff collaborated in the sampling design, fieldwork and in data analysis using database software (Microsoft Access), GIS software (Arcview 3.0) and statistical and graphics software (SYSTAT 8.0).
2. METHODS

2.1 Description of the study area

The study area comprised a 2500 km$^2$ area in PNG waters of Torres Strait, containing the northern Warrior Reefs and bounded in the south by the fisheries jurisdiction line (Fig. 2). The two main reef systems, Wapa and Auwamaza reefs are essentially raised sediment banks and support dense seagrass and algae communities; coral communities are restricted to the fringes of these reefs. The Great North East Channel, extending along the eastern margin of the Warrior Reefs, is deep (>20 m) and serves as a major shipping route. In contrast, the area to the west of the Warrior Reefs is generally shallow (<10 m). The waters of the study area are invariably turbid, particularly close to the PNG mainland, due to the outflow of several large PNG rivers, including the Fly river. For this reason the northern limit of the study area was set at the southern end of Bristow Island and ~5 km off the PNG coast in the north-west (Fig. 2).

2.2 Experimental Design

2.2.1 Allocation of sampling strata

The study area was divided into 12 sampling strata, based on seabed habitat and depth information from several CSIRO seabed surveys that are stored in the Torres Strait GIS. In addition, information on distribution of lobsters in 1989 was used to define strata. PNG NFA staff, with knowledge of the study area then assisted in determining the suitability of each stratum and refining their boundaries. The Gimini hard substrate and Kokope Reef strata were characterised by predominantly rocky seabed habitats (Fig. 3) and high densities of lobsters were recorded in these strata in 1989 (Fig. 4). Historical data showed that the seabed in five of the strata: Daru mud, Southwest Daru, West Warrior mud, West Auwamaza sand/rubble and Northeast channel trawl was mainly mud and sand (Fig. 3) – habitats which do not support lobsters. Further, no lobsters were seen in the west Warrior mud or West Auwamaza sand/rubble strata during the 1989 survey (Fig. 4). The Missionary Passage deep stratum was characterised by water depth >25m (Fig. 5). The Warrior near front, Wapa back reef, North Auwamaza edge and Moon Passage strata were located around the remaining reef edge to approximately 10 m depth.

The area covered by each strata (Table 1) was calculated using the ArcView GIS.
Figure 2. Map of the study area showing sample strata and sites allocated for the 1998 lobster survey.
Figure 3. Map of the study area showing sample strata and historical substratum data.

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Figure 4. Map of the study area showing sample strata and abundance of Panulirus ornatus at locations (mean of two transects) surveyed by CSIRO in 1989.
Figure 5. Map of the study area showing depth contours calculated from data collected during previous CSIRO surveys and hydrographic data.
Table 1. The area covered by each sampling strata, sampling density and number of transect sites allocated to each strata.

<table>
<thead>
<tr>
<th>Strata</th>
<th>Area (km$^2$)</th>
<th>Sampling density</th>
<th>Number of transects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daru mud</td>
<td>94.26</td>
<td>Low</td>
<td>2</td>
</tr>
<tr>
<td>Gimini hard substrate</td>
<td>287.56</td>
<td>High</td>
<td>36</td>
</tr>
<tr>
<td>Kokope reef</td>
<td>56.12</td>
<td>High</td>
<td>10</td>
</tr>
<tr>
<td>Missionary passage deep</td>
<td>121.02</td>
<td>Low</td>
<td>14</td>
</tr>
<tr>
<td>Moon passage</td>
<td>13.05</td>
<td>Low</td>
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<tr>
<td>North Auwamaza edge</td>
<td>6.49</td>
<td>High</td>
<td>6</td>
</tr>
<tr>
<td>Northeast channel trawl</td>
<td>501.34</td>
<td>Low</td>
<td>26</td>
</tr>
<tr>
<td>Southwest Daru</td>
<td>176.93</td>
<td>Low</td>
<td>6</td>
</tr>
<tr>
<td>Wapa back reef</td>
<td>28.64</td>
<td>Low</td>
<td>2</td>
</tr>
<tr>
<td>Warrior near front</td>
<td>121.89</td>
<td>Low</td>
<td>6</td>
</tr>
<tr>
<td>West Auwamaza sand/rubble</td>
<td>176.09</td>
<td>Low</td>
<td>10</td>
</tr>
<tr>
<td>West Warrior mud</td>
<td>890.50</td>
<td>Low</td>
<td>16</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>2473.87</strong></td>
<td></td>
<td><strong>136</strong></td>
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</tbody>
</table>

2.2.2 Sampling design

The sampling design in each of the sampling strata was essentially the same as that used by Pitcher et al (1992) to estimate the size of the *Panulirus ornatus* stock throughout Torres Strait in 1989. Their study showed that $4 \times 500$ m transects were the most cost-effective primary sampling unit and that two transects per location comprised the optimal allocation of replication. In the present study, locations were allocated to each of 12 sampling strata at either high (1 location per 20.25 km$^2$) or low (1 location per 36 km$^2$) density (Table 1), dependant on the main habitat in the strata, which determines its suitability as lobster habitat. Lobsters are very rarely found on sand and/or mud habitats (Pitcher et al 1992).

2.3 Field sampling

The survey of PNG waters of Torres Strait was conducted during 24 June to 1 July 1998. Sites were located using portable GPS navigators and sampled either by divers or with underwater video. Underwater video was used only at sites identified as unlikely lobster habitat or where water depth prevented diving.

A total of 76 sites were sampled by CSIRO and PNG NFA divers using hookah apparatus from a small dinghy. At each site two divers swam along a 500 m transect, measured using a Chainman II ® measuring device, and each diver counted all lobsters within 2 m of this line and speared as many as possible for later length-frequency analysis. At the conclusion of each transect the divers recorded habitat information and depth and the numbers of 1+ and 2+ lobsters seen but not speared.
A total of 57 sites were sampled with an underwater video towed ~1 m above the seabed from the vessel M. V. James Kirby. The number of lobsters was counted during a 500 m tow, measured using the ship’s GPS navigator. Habitat information and depth, measured using the ship’s depth sounder, was recorded at the conclusion of each tow.

2.4 Data analysis

2.4.1 Stock abundance estimate

The mean and variance of the lobster counts per transect were estimated for each sampling stratum. The total number of lobsters in each stratum was then calculated as the product of the mean count per transect and the number of possible transects in the stratum. The sum of these strata totals gave an estimate of the total number of lobsters in the study area. The variance of the overall abundance estimate was derived from variance estimates for each sampling stratum (see Pitcher et al, 1992 for details).

Stock biomass was calculated as the product of the stock abundance estimate and the mean tail weight of lobsters sampled during the survey.

Mean lobster abundances at sites surveyed in both 1989 and 1998 were compared using a paired t-test.

2.4.2 Analysis of size distribution

The size distribution of lobsters sampled by divers during the survey was analysed using the modal analysis program Mix 3.0 (MacDonald and Pitcher, 1979). The proportion and mean size of lobsters in each year-class was estimated. The size distribution of sampled lobsters was compared with size distributions of lobsters from the land-based and freezer-boat commercial catches to determine the range of sizes exploited by the fishery.
3. RESULTS

3.1 Stock abundance

*Panulirus ornatus* were observed in only 46 of the 133 transects sampled (Fig. 6), and in only 5 of the sampling strata; the combined area of these strata represented only 28% of the total area. However, the Missionary Passage deep stratum could not be sampled effectively due to a combination of water depth (25-38 m) and high turbidity at each of the sampling sites which reduced visibility to <1 m. This stratum was excluded from further analyses. Also, the Moon Pass stratum was merged with the Warrior near front stratum as the habitats in these strata were found to be very similar.

The highest densities of lobsters (55-60 per ha) were recorded at two deep (>15 m) sites in the Gimini hard substrate stratum (Fig. 6), and high densities were also recorded at sites on the exposed reef edges. No lobsters were found in the Daru mud, Northeast channel trawl, Southwest Daru, Wapa back reef and West Warrior mud strata (38 sites); likely due to the low cover of hard seabed (Fig. 7, see Appendix A), in these strata.

The estimate of the *Panulirus ornatus* stock in PNG waters of Torres Strait was ~460,000, of which 58% came from the Gimini hard substrate stratum, which comprised only 12% of the total area (Table 2). The 95% confidence interval (± 50 %) was much larger than expected, given that Pitcher et al. (1992) recorded an interval of ± 21% for the entire Torres Strait in 1989. However, the precision (se/mean) of the 1998 estimate was adversely affected by a much lower abundance of lobsters in that year. Lobsters were more than twice as abundant in 1989 (13.75 per ha) compared to 1998 (5.62 per ha) at the 16 repeated sites (Paired t-test, p=0.04).

When converted to a weight estimate, given a mean tail weight of 297 grams for sampled lobsters, the stock biomass was ~137 t. Since there is currently no enforced minimum legal-size for *Panulirus ornatus* in the PNG fishery, fishers exploit most of the population, and between August 1997 and July 1998 the fishery catch was ~80 t, which indicates that currently about 60% of the stock is exploited.

3.2 Geographic distribution of recruiting and fished lobsters

Of the 46 sites where *Panulirus ornatus* were observed during the survey, 16 (~30 %) supported both recruiting (1+ year old) and fished (2+ and 3+ year old) lobsters (Fig. 8). Of the 5 sampling strata where lobsters were observed the Gimini hard substrate stratum had the highest percentage of fished (2+ and 3+) lobsters (61%). Nevertheless, recruiting and fished lobsters appeared to occupy similar habitats in the study area and it would be impossible to designate closed areas to conserve recruiting lobsters without restricting access to 2+ lobsters. Of a total of 147 lobsters observed during the survey, 44 (~30%) were found in water depths >20 m and up to 35 m; depths that are not readily accessible to most commercial lobster divers. It is also likely that lobsters inhabit some areas in the Missionary Passage deep stratum that would be inaccessible to divers.
Figure 6. Map of the study area showing sample strata and abundance of Panulirus ornatus at each site sampled in 1998.
Figure 7. Map of the study area showing sample strata and relative proportion of each substratum type recorded at each sample site during the 1998 survey.
Figure 8. Map of the study area showing sample strata and proportion of 1+ and 2+ year old lobsters at each site sampled in 1998. The size of each pie diagram is proportional to total abundance (see Fig. 6).
Table 2. Calculation of stock size and variance estimates for the PNG Torres Strait study area from transect survey data, and estimation of stock biomass from number and mean weight of tails. Prop.: proportional area of strata; N: number of possible transects in strata; n: number of transects sampled; $S^2_{loc}$: sample variance (location); se: standard error (stratum); Stock: estimated number of lobsters (stratum).

<table>
<thead>
<tr>
<th>Strata</th>
<th>Area</th>
<th>Prop.</th>
<th>N</th>
<th>n</th>
<th>Mean</th>
<th>$S^2_{loc}$</th>
<th>se</th>
<th>Stock</th>
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<td>0.000</td>
<td></td>
<td></td>
<td>0</td>
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<tr>
<td>Gimini hard substrate</td>
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<td>143779</td>
<td>38</td>
<td>1.868</td>
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<td>Warrior near front</td>
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<td>0.000</td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

2352.86 1.0000 1176429 126 0.009778 459991

Standard error  = $\sqrt{0.009778} = 0.0989$
95% CI = $t_{0.05} \times 1176429 \times 0.0989 = \pm 228475$ lobsters
Percent error = $(228475/459991) \times 100 = \pm 50$
Mean tail weight (297 g)
Stock estimate  = 0.297 $\times$ 459991 = 136617 kg

3.3 Size distribution

The size frequency distribution of 102 lobsters sampled during the survey showed essentially two modes (Fig. 9): the left mode comprised the 1+ year-class (Mean tail width 54 mm) and made up 56% of the population while the right mode comprised the 2+ and 3+ year-classes (Mean tail width 76 mm), which comprised 42% and ~2% of the population respectively (derived using Mix 3.0). By comparison, the size distributions of the land-based and freezer boat fishery catches showed land-based fishers (free-divers) take mainly 1+ lobsters, while freezer boat fishers (using hookah equipment) take mainly 2+ lobsters. In combination, these sectors of the fishery exploit the full size-range of lobsters in the population. This is corroborated by size distributions of lobsters caught each month in 1997 by Daru-based divers (Appendix B), which shows all lobsters greater than ~35mm tail width are exploited each month.

3.4 Distribution of Pinctada maxima and holothurians

A total of 16 pearlshell *Pinctada maxima* were observed during the 1998 survey (Appendix C) and 15 of these were found in the Gimini hard substrate stratum. A total of 281 holothurians, made up from 12 species were observed during the survey, mainly restricted to habitats near the reef edges (Appendix D). However, of the species observed only 2 were of high commercial value *Holothuria scabra* and *Holothuria nobilis* and comprised <2% of the total, while 6
species; *Holothuria atra*, *Holothuria edulis*, *Stichopus variegatus*, *Stichopus chloronotus*, *Actinopyga mauritiana* and *Actinopyga echinites* were of low commercial value and comprised 80% of the total.

![Size frequency distributions of Panulirus ornatus](image)

**Figure 9.** Size frequency distributions of *Panulirus ornatus* sampled during the PNG Torres Strait survey in June/July 1998, showing the component age classes, and in the catches of the land-based and freezer boat fisheries in the same months.
4. DISCUSSION AND CONCLUSIONS

The survey of the abundance of *Panulirus ornatus* in PNG waters of Torres Strait was successfully completed by CSIRO and PNG NFA staff who counted lobsters at 133 sites in the ~2500 km\(^2\) study area during June/July 1998. Lobsters were found in a restricted range of habitats, on deep rocky seabed or near the more exposed reef edges in only 5 of the original sampling strata; at only 46 (~35\%) sites. The seabed habitat to the west and east of the Warrior Reefs was predominantly mud/sand and no lobsters were found there.

The estimate of lobster abundance in PNG waters of Torres Strait was 460,000 (± 50 \%), of which 58 \% came from the Gimini hard substrate stratum, which represented only 12 \% of the total area. The estimated stock biomass, given a mean tail weight of the sampled lobsters of 297 g, was ~137 t. The resulting estimate of stock per unit area (138 kg/km\(^2\)) is much lower than that estimated for legal-sized *P. ornatus* in 1989 (~375 kg/km\(^2\); Pitcher et al. 1992) and comparison of the lobster counts at 16 sites repeated in 1989 and 1998 confirmed that lobsters were much less abundant (40\%; 5.62 cf. 13.75 per ha) in 1998. The low precision (95 \% CI = 50\%) achieved in this study was a result of the low abundance, particularly due to the large number of transects without lobsters. Had lobsters been as abundant in 1998 as in 1989 the 95\% CI would have been ±20.4\%. Nevertheless, the precision of the lobster stock estimate compares favourably with other large-scale studies such as that of Smith and van Nierop (1986) who estimated the abundance of *P. argus* in a 60,000 km\(^2\) area with 95 \% CI's of 80 to 120\%.

The size distributions of lobsters in the land-based and freezer boat sectors of the PNG fishery compared with the size distribution of sampled lobsters showed that the fishery exploits the full size-range of the population. The fishery catch in 1997/98 was ~ 80 t which indicates fishers currently exploit 60 \% of the standing stock (~137 t). However, this exploitation rate may be a slight over-estimate since the Missionary Passage deep stratum, which likely houses lobsters, was not surveyed in this study.

Recruiting (1+) and fished (2+ and 3+) lobsters were found to occupy the same habitats and it would be impossible to designate closed areas to conserve recruits without restricting access to 2+ lobsters. However, about 30\% of the lobsters observed were found in water depths >20 m; depths not readily accessible to most commercial divers. Thus, lobsters in these deep areas comprise a reservoir population that would not be exploited unless these lobsters move into shallower habitat.

The effect of imposing a minimum size limit to increase yield per recruit (YPR) was recently assessed (see Final Report No FIS/96/81) using a fishery model developed for the Australian fishery (see Pitcher et al. 1997). The model showed that setting and enforcing a minimum size equivalent to that set for the Australian fishery (100 mm tail length ≈ 52 mm tail width) would only significantly increase YPR if fishing mortality was extremely high (F>1.0, equivalent to ~60\% exploitation). The current study indicates that fishing mortality has reached this level (exploitation ~60 \%) and it is therefore likely that enforcing a size limit, particularly in the land-based sector, would increase YPR and increase total annual catch.

Yield per recruit might also be increased by implementing a seasonal closure during October, November when the population is comprised of small 1+ lobsters (Appendix B). Such a closure would allow each lobster to grow ~100 grams (growth ≈50 g per month, CSIRO unpublished
data) before being fished. Currently, a two month closure (Oct, Nov) is enforced in Australian waters but applies only to hookah divers. A PNG closure would have to apply to all divers, since most of the catch taken by Daru-based free-divers is comprised of 1+ lobsters. The socio-economic effects of introducing a seasonal closure would need to be determined prior to implementing such a closure.

This study provides a baseline for future studies of the abundance and distribution of *P. ornatus* and status of the PNG lobster fishery and established sampling sites that may be used for future fishery-independent surveys of the lobster stocks. Such surveys would compliment surveys conducted annually by CSIRO in Australian waters of Torres Strait and would complete the coverage of Torres Strait.

5. **RECOMMENDATIONS**

The current minimum legal size for *Panulirus ornatus* (100 mm tail length, as prescribed in the PNG Torres Strait Spiny Lobster Fishery Plan) should be enforced in both the land-based and freezer boat sectors of the fishery, to increase yield per recruit (YPR) and total annual catches.

Fishery-independent surveys should be conducted regularly and concurrently to the annual population surveys in Australian waters to provide information on the status of the entire Torres Strait lobster stock for joint management of the resource and assessment of long-term potential yield.

Size frequency information should be gathered monthly from the Daru Island processors to compliment commercial catch monitoring and fishery-independent surveys and allow assessment of the age composition of commercial catches and year-class strengths from abundance data (CPUE or relative abundance).

6. **REFERENCES**


### APPENDIX A

Numbers of sites sampled, mean depth, mean percent cover of each substratum type, % megabenthos, algae and seagrass and number of pearlshell observed at each of the sampling strata during the 1998 survey of the PNG waters of Torres Strait.

<table>
<thead>
<tr>
<th>STRATA</th>
<th>Sites</th>
<th>Depth (m)</th>
<th>Silt</th>
<th>Sand</th>
<th>Rubble</th>
<th>Boulders</th>
<th>Consolidated rubble</th>
<th>Pavement</th>
<th>Live coral</th>
<th>Megabenthos</th>
<th>Algae</th>
<th>Seagrass</th>
<th>Pearlshell</th>
</tr>
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<tbody>
<tr>
<td>Daru mud</td>
<td>2</td>
<td>12.0</td>
<td>100.0</td>
<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Gimini hard substrate</td>
<td>38</td>
<td>16.4</td>
<td>23.1</td>
<td>34.1</td>
<td>21.3</td>
<td>0.3</td>
<td>19.4</td>
<td>0.7</td>
<td>1.2</td>
<td>8.4</td>
<td>11.2</td>
<td>1.0</td>
<td>15</td>
</tr>
<tr>
<td>Kokope Reef</td>
<td>13</td>
<td>15.1</td>
<td>23.4</td>
<td>31.5</td>
<td>15.2</td>
<td>0.0</td>
<td>14.6</td>
<td>0.0</td>
<td>7.7</td>
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<td>3.1</td>
<td>0.2</td>
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<tr>
<td>Missionary Passage deep</td>
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<td>30.8</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
</tr>
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<td>18.0</td>
<td>6.0</td>
<td>42.0</td>
<td>25.0</td>
<td>6.0</td>
<td>18.0</td>
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<td>3.0</td>
<td>8.2</td>
<td>18.4</td>
<td>5.2</td>
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<td>Northeast channel trawl</td>
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<td>Warrior near front</td>
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<td>11.5</td>
<td>31.3</td>
<td>38.8</td>
<td>13.1</td>
<td>1.1</td>
<td>11.7</td>
<td>2.3</td>
<td>1.9</td>
<td>3.4</td>
<td>8.4</td>
<td>1.1</td>
<td>0</td>
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<td>West Auwamaza sand/rub</td>
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<td>14.0</td>
<td>30.4</td>
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<td>4.1</td>
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<td>0</td>
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<td>67.8</td>
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<td>0.0</td>
<td>0.3</td>
<td>1.4</td>
<td>0.4</td>
<td>0.0</td>
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APPENDIX B

Size distributions of *Panulirus ornatus* from commercial catches returned to Daru, PNG in each month during 1997.
Appendix C. Map of the study area showing sample strata and abundance of Pinctada maxima at sites sampled during the 1998 lobster survey.
Appendix D. Map of the study area showing sample strata and abundance of holothurians at sites sampled during the 1998 lobster survey.